IWIFR SEMI ANNUAL
PROGRESS REPORT

April 1, 1982 - September 30, 1982

# INTEGRATED WILDLIFE INTENSIVE FORESTRY RESEARCH

Province of British Columbia

*A cooperative project between the Ministries of Environment and Forests*

# IWIFR SEMI ANNUAL PROGRESS REPORT

April 1, 1982 - September 30, 1982

R. Ellis, editor

October 1982

Province of British Columbia

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PROGRESS REPORT

TITLE (E.P. #):

Roosevelt Elk/Intensive Forestry Interactions. (E.P. 912)

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PERIOD COVERED:

April 1 - September 30, 1982

## 1 SUMMARY

A total of 21 elk are presently radio collared in the study area including 18 cows and 3 mature bulls. Tests on radio telemetry accuracy are continuing. Preliminary analysis of data has been conducted for a pilot area to examine different methods of assessing habitats and elk use vs availability of habitat types.

Results of the first year of food habits and fecal nitrogen data have been obtained and are currently under analysis. Most of the permanent weather stations will likely be discontinued due to the inability of the thermometers to register slight differences in temperature between stands differing in silvicultural treatment.

Familiarization and initial gaming with the ESSA elk model have been undertaken.

## 2 INTRODUCTION

The potential for maintaining and increasing elk (Cervus elaphus roosevelti) numbers on Vancouver Island is dependent on the provision of habitat requirements through intensive forest management. Management-oriented research on elk ecology and intensive forestry interactions is required to provide the biological information necessary for effective integrated resource management.

This report outlines the progress made during the first half of the second year of work under the IWIFR elk project. We would like to acknowledge Ministry of Forests statisticians Val Fletcher and Dr. Howard Stauffer for their comments on portions of this report.

## 3 OBJECTIVES

The general objective of the elk project is to collect and provide information on elk habitat use in immature forests, and to assess the response of elk habitat use and numbers to the various silvicultural treatments associated with intensive forestry.

Specific objectives for the second year of the elk project include:

a) documenting seasonal habitat use and seasonal movements of individual elk inhabiting immature forests;
b) documenting food habits and animal condition for 3 herds;
c) documenting (in conjunction with the habitat crew) available habitat types within intensively monitored weekly home ranges so that use vs. availability inferences of habitat preference can be made;
d) documenting population status and trends of 3 herds;
e) documenting seasonal activity patterns and activity-habitat relationships of radio collared elk;
f) documenting distribution and diets of predators over 3 herd areas.

## 4 METHODS

Methodologies associated with monitoring elk habitat use and movements, food habits, condition, predator distribution, and habitat assessment were presented in the revision to the 1982 annual working plan.

## 5 RESULTS AND DISCUSSION

### 5.1 Radio Telemetry

The total number of radio collared elk remains at 21 with no losses occurring due to dropped collars or mortality since the last reporting period. This total includes 18 mature cows and 3 mature bulls. Teeth from the 7 animals radio collared in 1982 have been forwarded for sectioning to estimate ages.

Tests of radio telemetry accuracy (n=16) are still being conducted. Generally, where direct line of sight radio fixes can be obtained, accuracy is within 50 m of the planted collar. However, where direct line of sight fixes cannot be obtained (ie. collar in ravine, behind hill, etc.) accuracy decreases substantially and error polygon centres can be 300-400 m from the planted collar.

### 5.2 Habitat Utilization

Home range analyses using the HOME program (Harestad 1981) on the BCSC computer are presently being done. No results are available yet.

Intensive 24-hour monitoring over one week periods has been done for seven individual elk. Five out of seven of these individuals were inhabiting lower elevation immature forests during the monitoring period. The 5-day home ranges of two individuals were selected as a pilot area in which preliminary habitat assessments were conducted by the habitat project. Twenty habitat types were derived and mapped for the pilot area. Table 1 shows percent use by habitat type for ten grouped types. Habitat selection analyses are presently incomplete.

5.3 Food Habits

Results of diet analyses by season and herd area (microhistological fecal analysis conducted by Washington State University's Wildlife Habitat Lab) are presented in Figure 1. Preliminary analysis of these data indicate the following general trends;

- shrubs appear to increase in importance in summer from spring, decrease in the fall, and increase again in early winter;
- conifers appear highest in importance in the early winter;
- use of grasses for the 2 migratory herds was highest in the spring and summer, declining as the year progresses;
- spring and fall use of grasses by the resident herds was much higher than the 2 migratory herds, and comprised a large portion of the fall diet while grasses were relatively unimportant in the fall diet of migratory animals;
- ferns were the primary food item in the spring, shrubs and forbs in the summer, and conifers in the winter. Fall food habits appear quite variable depending on the area.

These data will probably be used to assess the forage component of the habitat value of a stand during subsequent habitat assessments.

Figure 2 illustrates the results of three paired rumen/fecal samples obtained from hunter killed animals. The paired analyses were conducted to compare the results obtained by the microhistological rumen and fecal methods of determining food habits. Macroscopic analysis of rumen contents for the same animals will also be conducted by the Research Section of the Fish and Wildlife Branch to compare this technique with the microanalysis methodologies.

Examination of the results of the microrumen and microfecal methods shows major differences between paired samples. Possible reasons for the discrepancies include; differential digestibility of forage species, differential rates of passage of food items, changes in the selection of forage items shortly before collection of the samples, and misidentification of forage species by the lab.

Table 1. Percent use of seral stages (n=70) on summer range (CWH, wet) in early July by migratory cow elk

| Seral Stage | Moisture Regime | (stems/ha) Density | (m) Height | Understory | % Use |
|---|---|---|---|---|---|
| Meadow-bog | Hygric | N/A | N/A | Sphagnum, Myrica gale, grasses | 15.7 |
| Alder-gravel bar complex | Hygric | >1000 | 8-15 | Rubus spectabilis, Rubus parviflorus | 10.0 |
| 4-6 Yr. Abies amabilis | Mesic-Hygric | 500-1000 | < 3 | Vaccinium spp., Blechnum spicant | 5.7 |
| 6-8 Yr. A.amabilis | Mesic-Hygric | 500-1000 | 2-4 | Salix spp., R.spectabilis, grasses | 4.3 |
| 8-10 Yr. A.amabilis-Tsuga heterophylla | Mesic | >1000 | < 3 | R.spectabilis, Vaccinium spp., Cornus canadensis | 0 |
| 10-12 Yr. A.amabilis | Xeric-Mesic | 500-1000 | < 3 | Linnaea borealis, Vaccinium parvifolium | 0 |
| 12-18 Yr. A.amabilis-T.heterophylla with Pseudotsuga menziesii (in-fill planted) | Mesic | >1000 | ≤ 8 | L.borealis, C.canadensis, Pteridium aquilinum | 10.0 |
| 8-10 Yr. P.menziesii | Mesic | >1000 | 2-4 | P. aquilinum, Anaphalis margaritacea, grasses | 10.0 |
| 10-15 Yr. A.amabilis-P.menziesii | Mesic-Hygric | 500-1000 | <5 | Salix spp., C.canadensis, R.spectabilis, grasses | 22.9 |
| 50-60 Yr. A.amabilis-T.heterophylla | Mesic | >1000 | 30 | minimal understory | 2.8 |
| Mature A.amabilis-T.heterophylla | Xeric-Mesic-Hygric | < 500 | 35-45 | Vaccinium ovalifolium, C.canadensis, B.spicant | 18.6 |

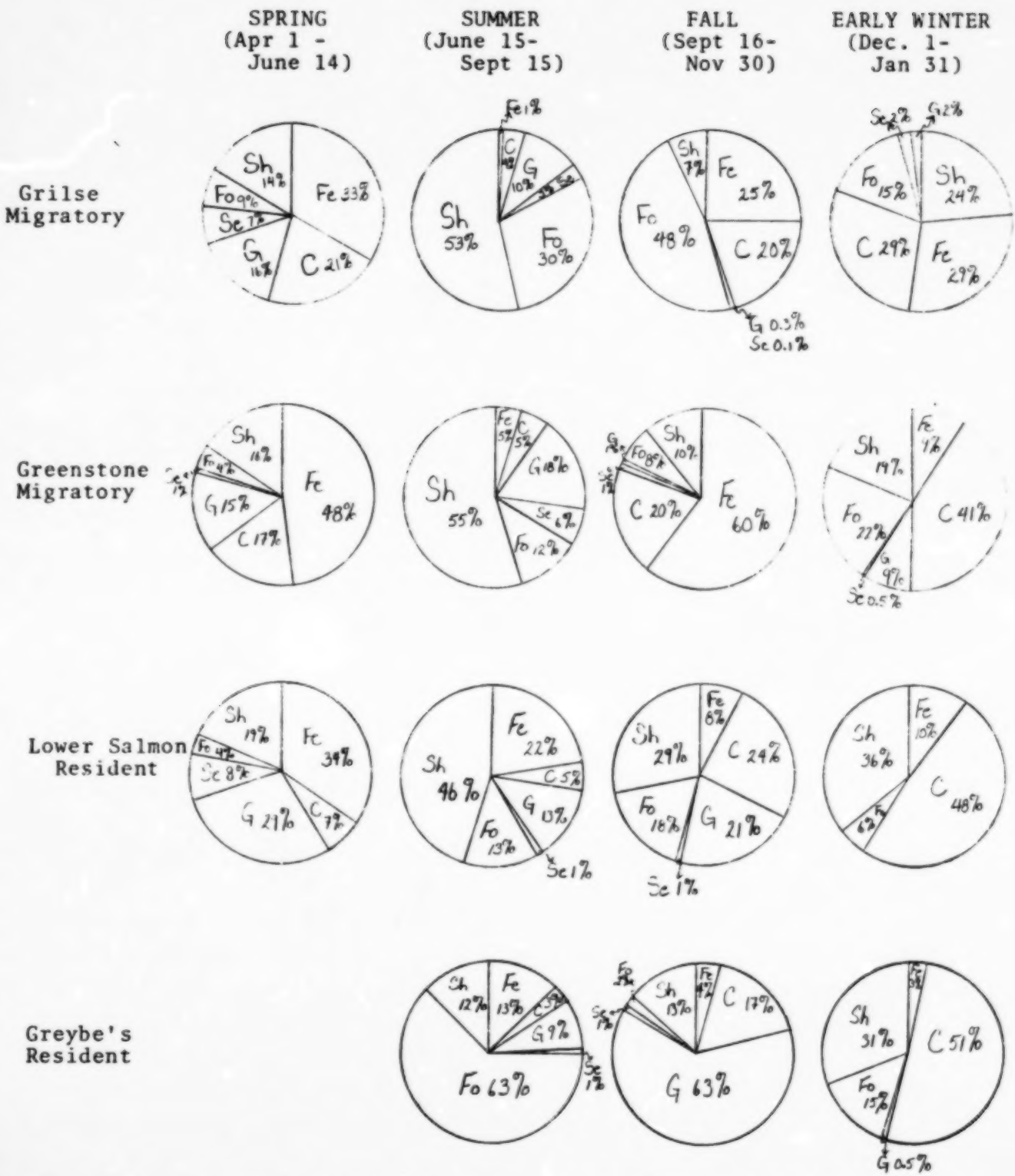


Figure 1. Percent of diet by forage type for the 4 major herds within the study area (Fe=ferns; C=conifers; Se=sedges; Fo=forbs; Sh=shrubs; G=grasses).

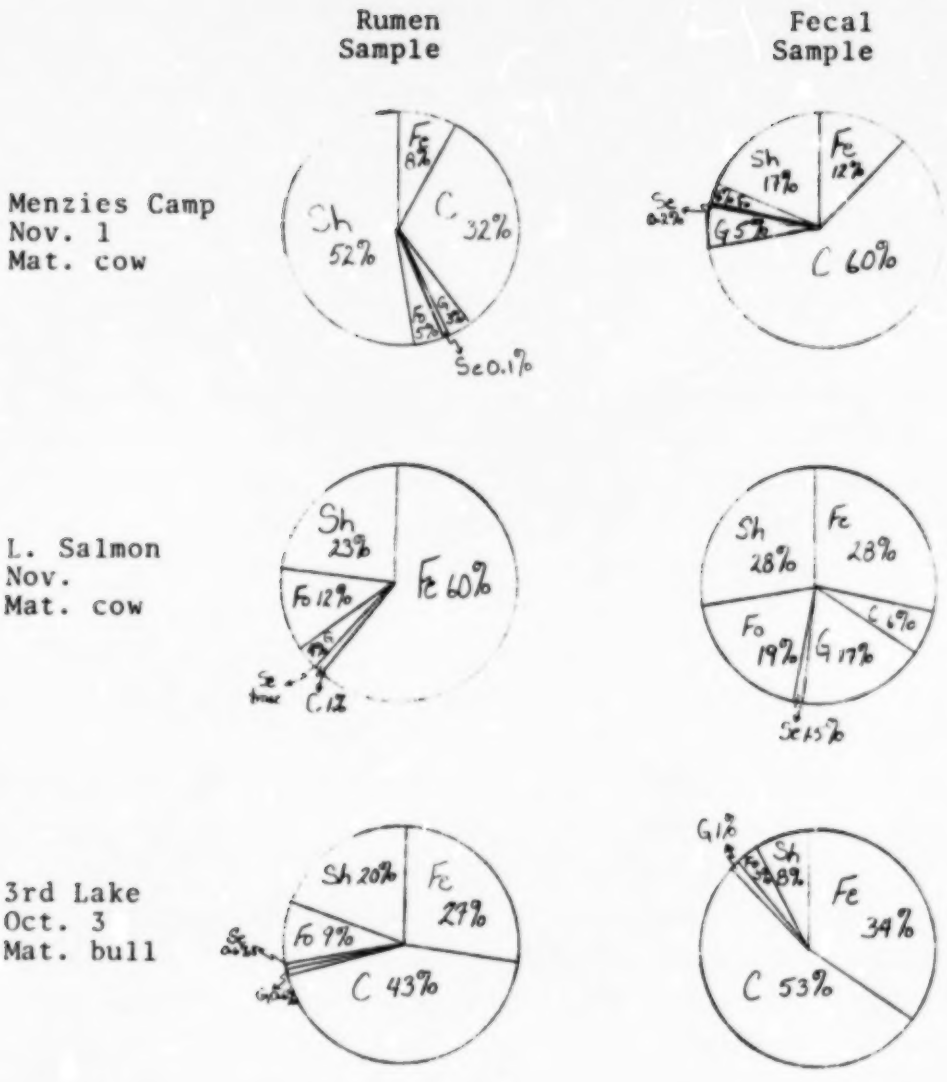


Figure 2. Comparisons of results (% of diet) between the microfecal and microrumen methods of food habits analysis for 3 paired samples (Fe=ferns; C=conifers; G=grasses; Se=sedges; Fo=forbs; Sh=shrubs).

Differential digestibility could account for the relatively higher occurrence of coniferous species in the feces than the rumen. However, other discrepancies between the rumen and fecal methodologies are not so easily explained.

Kessler et al. (1981) found variable agreement between the microrumen, macorumen, and microfecal methodologies. They concluded that fecal analysis provides adequate qualitative diet information, but in order to determine quantitative information, correction terms may need to be introduced.

5.4 Animal Condition Indices

Results of fecal nitrogen (N) analysis conducted by Washington State University were examined for statistical soundness of the present sampling regime. The coefficients of variation (CV's) for the 22 collections to date (ie. variation between individuals within a group) ranged from 4-15%, most being 6-8%. This indicates that a confidence level of 95% can be obtained with the current sample size (8-10 individuals sampled within a group) and sample error (5-10%) for the seasons analyzed to date (spring, summer, fall and early winter).

Where complete collections exist (ie. the Greenstone and Grilse migratory herds) markec seasonal trends in fecal N values were noted, peaking sharply during early to mid July at a value of approximately 4.6%. The values than decline steadily and relatively more slowly as the year progresses. Late winter samples have not yet been analyzed to complete the annual cycle of fecal N values. More detailed analyses of between area comparisons are currently being conducted.

There was no significant linear relationship between fecal N values and either the serum urea nitrogen (SUN) values of immobilized animals or the kidney fat index (KFI) of hunter killed animals. Altered SUN values due to urea reacycling may account for the lack of agreement between the SUN and fecal N indices. Also, many kidney samples collected by hunters were either insufficient or incorrectly prepared possibly explaining the differences between the KFI and fecal N indices.

5.5 Population

Sample sizes for estimating calf:cow ratios were derived using the formula (Cochran 1977),

$$n = \frac{No}{1 + (No./N)} \quad \text{where } No = t^2 \frac{pq}{d^2}$$

Here, N is the etimated herd size, t is the t value for the appropriate confidence interval, p is the calf:100 cow ratio, q is 1-p, and d is the maximum desired error in the calf:100 cow ration. Sample sizes (S) for estimating calf:100 cow ratios with 3 percent error and 80% confidence are shown for each herd in Table 2.

Table 2. Calf:100 cow ratios from late August 1982 surveys

| Herd | N[a] | S[b] | n[c] | calves: 100 cows | SE | 80% C.I.[d] |
|---|---|---|---|---|---|---|
| Grilse | 120 | 95 | 109[e] | 49.3 | 2.5 | 46.1-52.5 |
| Greenstone | 80 | 68 | 58 | 48.7 | 3.4 | 44.4-53.0 |
| Lower Salmon | 40 | 36 | 24 | 50.0 | 6.5 | 41.7-58.3 |
| Greybe's | 30 | 28 | 13 | 33.3 | 10.2 | 20.2-46.4 |

[a] population estimate of total number of cows and calves in herd based on composite information from Petersen estimates, radio telemetry, and general knowledge of the herd.

[b] estimated sample size required for estimating calf:100 cow ratio with 3% error and 80% C.I.

[c] sample size of cows and calves (n = cows + calves) observed

[d] 80% confidence interval

[e] n adjusted for the capture of two calves.

Calf:100 cow ratios for late August surveys are also shown in Table 2. Confidence intervals are acceptable for the Grilse, Greenstone and Lower Salmon herds, but too wide for the Greybe's herd due to low sample size. Standard errors were calculated using the formula (Cochran 1977),

$$SE = \sqrt{\frac{N-n}{(n-1)N}} \quad pq$$

5.6 Activity Budgets

Based on preliminary data, a sampling scheme for collecting activity data has been derived. Activity data will be collected on tip switch collars only. This is because of an amplitude-distance problem detected in field tests which indicates it is not possible to detect activity through changes in amplitude at distances under 300-400 m. The tip switch collars change the period of the radio signal under three activity situations: head up, head down and inactive for greater than 10 minutes. From recordings of these signals it will be possible to detect length and duration of feeding periods and length and duration of bedding periods at any distance. During a 24-hour-5-day monitoring period, two 24-hour recordings of an individual's activity will be made.

5.7 Predation

During the reporting period, scats were collected on roads when observed. However, due to decreased field work, and intensive monitoring periods which only covered small areas and road sections, both wolf and bear scats collected declined form the 1981 summer collection period. Wolf scats observed (n=16) were almost equal to the 1981 winter period (n=15).

The number of bear scats collected (n = 48) was also less than last summer's collection period (n=169).

No cougar observations were made.

5.8 Weather

Statistical analysis of last year's weather station data indicated there was little variation between temperatures in adjacent stands. Although some significant differences were shown by analysis (see Appendix A), inability of the thermometers to measure small temperature variations could account for most differences. Only temperature variations between slash and timber proved to have measureable significant differences, therefore these weather stations will continue to be maintained. All others are under consideration to be discontinued.

Rainfall measurements were found to be highly variable within weather station sites. This variability made comparisons between adjacent weather stations of little value.

Snow measurements taken at permanent weather stations were also found to be extremely variable within weather station sites. Open site snow measurement stations set up independently of permanent weather stations were found to show less variability and more accurately indicate snowfall trends. These measurements will be continued during the coming winter.

5.9 Computer Modeling

Familiarization and intial gaming with the ESSA elk model has been undertaken. Comments on the model and suggestions for improvements, including the capability for making multiple runs, have been submitted to P. MacNamee (ESSA Ltd.).

## 6 LITERATURE CITED

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# 7 APPENDIX

Summary of between station comparisons of temperature data for 9 permanent weather stations.

## FRY LAKE WEATHER STATIONS

(Elevation: Approximately 600')

Station #1 - unthinned Fir; established 1947
Station #2 - thinned Fir; established 1947, spaced 1977

| Station (#) | Month | MAXIMUM MONTHLY TEMPERATURE | | | | | MINIMUM MONTHLY TEMPERATURE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. Temp. ($\bar{x}$) | S.D.) | Max. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) | Min. Temp. ($\bar{x}$) | S.D.) | Min. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) |
| 1 | June 81 | 14.3 | 3.0 | 1.26 | Signifi. | 2>1 | 8.5 | 1.3 | .113 | not signif. | ---- |
| 2 | | 15.5 | 3.4 | | | | 8.6 | 1.3 | | | |
| 1 | July 81 | 19.7 | 4.0 | 1.55 | Signifi. | 2>1 | 10.5 | 2.3 | .052 | not signif. | ---- |
| 2 | | 21.2 | 4.0 | | | | 10.5 | 2.2 | | | |
| 1 | Aug. 81 | 21.3 | 5.8 | 1.9 | Signifi. | 2>1 | 11.4 | 1.9 | .13 | significant | 2>1 |
| 2 | | 23.2 | 6.3 | | | | 11.5 | 1.8 | | | |
| 1 | Sept 81 | 15.2 | 4.4 | .84 | Signifi. | 2>1 | 9.0 | 2.2 | .097 | not signifi. | ---- |
| 2 | | 16.1 | 4.8 | | | | 8.8 | 2.0 | | | |
| 1 | Oct. 81 | 10.0 | 2.1 | .64 | Significant | 2>1 | 4.2 | 2.6 | .093 | not signifi. | ---- |
| 2 | | 10.6 | 2.2 | | | | 4.4 | 2.6 | | | |
| 1 | Nov 81 | 5.9 | 2.4 | .36 | Significant | 2>1 | 2.8 | 2.9 | .22 | significant | 2>1 |
| 2 | | 6.2 | 2.4 | | | | 3.0 | 3.1 | | | |
| 1 | Dec 81 | 0.6 | 2.2 | .06 | Not signifi. | --- | -2.5 | 2.2 | .71 | significant | 2<1 |
| 2 | | 0.6 | 2.5 | | | | -3.0 | 2.3 | | | |
| 1 | Jan 82 | -1.0 | 3.4 | .56 | Significant | 2>1 | -4.3 | 4.6 | .03 | not signifi. | ---- |
| 2 | | -0.4 | 3.6 | | | | -4.3 | 5.0 | | | |
| 1 | Feb 82 | 1.5 | 1.9 | .8 | Significant | 2>1 | -2.2 | 2.6 | .52 | Significant | 2>1 |
| 2 | | 2.3 | 1.9 | | | | -1.7 | 2.6 | | | |
| 1 | Mar 82 | 5.5 | 2.1 | .96 | Significant | 2>1 | -1.6 | 1.3 | .16 | Not signifi. | ---- |
| 2 | | 6.5 | 2.4 | | | | -1.7 | 1.7 | | | |
| 1 | Apr 82 | 7.3 | 3.4 | 1.9 | Significant | 2>1 | -1.1 | 1.7 | .86 | Significant | 2>1 |
| 2 | | 9.2 | 3.8 | | | | - .2 | 1.9 | | | |

## THIRD LAKE WEATHER STATIONS

Station #3 - Upper; Elevation 1300'; HB(Natural) established 1958
Station #4 - Lower; Elevation 1300'; HB Established 1958, spaced 1969

| Station (#) | Month | MAXIMUM MONTHLY TEMPERATURE | | | | | MINIMUM MONTHLY TEMPERATURE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. Temp. ($\bar{x}$ S.D.) | | Max. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) | Min. Temp. ( $\bar{x}$ S.D.) | | Min. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) |
| 3 | June 81 | 14.9 | 3.2 | .34 | Signifi. | 3>4 | 7.3 | 7.8 | .76 | Signifi. | 3>4 |
| 4 | | 14.5 | 3.2 | | | | 6.5 | 1.8 | | | |
| 3 | July 81 | 24.9 | 0.8 | 1.2 | Not Sign. | ---- | 14.0 | 4.6 | 3.92 | Not Signifi. | ---- |
| 4 | | 20.3 | 4.2 | | only 3 samples | | 8.5 | 2.9 | | only 4 samples | |
| 3 | Aug 81 | No Data | | | | | | | | | |
| 4 | | | | | | | | | | | |
| 3 | Sept.81 | 14.9 | 5.0 | 1.29 | Significant | 3>4 | 6.7 | 2.4 | 1.3 | Significant | 3>4 |
| 4 | | 14.8 | 5.0 | | | | 6.3 | 2.8 | | | |
| 3 | Oct. 81 | 10.1 | 2.4 | 1.02 | Significant | 3>4 | 2.9 | 2.9 | 1.53 | Significant | 3>4 |
| 4 | | 9.1 | 2.7 | | | | 1.5 | 2.7 | | | |
| 3 | Nov 81 | 5.8 | 2.9 | .14 | Not Signifi. | ---- | 1.7 | 2.9 | .52 | Significant | 3>4 |
| 4 | | 5.6 | 2.9 | | | | 1.2 | 2.8 | | | |
| 3 | Dec 81 | 1.1 | 2.6 | .92 | Significant | 3>4 | -2.7 | 3.2 | 1.11 | Significant | 3>4 |
| 4 | | 0.2 | 2.4 | | | | -3.8 | 3.7 | | | |
| 3 | Jan 82 | -0.2 | 3.1 | .87 | Significant | 3>4 | -3.9 | 5.0 | 1.36 | Significant | 3>4 |
| 4 | | -1.1 | 3.8 | | | | -5.2 | 6.0 | | | |
| 3 | Feb. 82 | 1.5 | 1.9 | .41 | Not Signifi. | ---- | -2.7 | 3.3 | .23 | Not Signifi. | ---- |
| 4 | | 1.9 | 2.2 | | | | -3.0 | 3.9 | | | |
| 3 | Mar 82 | 5.5 | 1.7 | .71 | Significant | 3<4 | -2.2 | 1.8 | .72 | Significant | 3>4 |
| 4 | | 6.2 | 2.0 | | | | -2.9 | 2.4 | | | |
| 3 | Apr 82 | 7.3 | 3.5 | .34 | Significant | 3<4 | -1.3 | 1.5 | 1.08 | Significant | 3>4 |
| 4 | | 7.6 | 3.9 | | | | -2.4 | 1.8 | | | |

LONG LAKE MAINLINE-BRANCH 146

(Elevation Approximately 1200')

Station #5 - Unthinned FHB; Established 1958 (Natural)
Station #6 - Thinned FHB; Established 1958, spaced 1971

| Station (#) | Month | MAXIMUM MONTHLY TEMPERATURE | | | | | MINIMUM MONTHLY TEMPERATURE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. Temp. ($\bar{x}$ S.D.) | | Max. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) | Min. Temp. ($\bar{x}$ S.D.) | | Min. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) |
| 5 | June 81 | 14.2 | 3.4 | .950 | Not Signifi. | ---- | 8.0 | 1.2 | .714 | Not Signifi. | ---- |
| 6 | | 13.9 | 2.9 | | | | 8.0 | 1.3 | | | |
| 5 | July 81 | 19.9 | 4.0 | 1.09 | Significant | 5>6 | 9.9 | 2.1 | .24 | Significant | 5>6 |
| 6 | | 18.8 | 3.4 | | | | 9.7 | 2.0 | | | |
| 5 | Aug 81 | 21.7 | 5.9 | .95 | Significant | 5>6 | 11.0 | 2.1 | .145 | Significant | 5>6 |
| 6 | | 20.7 | 5.3 | | | | 10.8 | 2.1 | | | |
| 5 | Sept 81 | 15.1 | 4.8 | .72 | Significant | 5>6 | 8.6 | 2.3 | .37 | Significant | 5>6 |
| 6 | | 14.4 | 4.5 | | | | 8.3 | 2.5 | | | |
| 5 | Oct 81 | Insufficient Data | | | | | | | | | |
| 6 | | " | " | | | | | | | | |
| 5 | Nov 81 | 3.9 | 2.0 | .25 | Not Signifi. | ---- | .7 | 1.9 | .18 | Not Signifi. | ---- |
| 6 | | 6.2 | 2.7 | | | | 2.9 | 2.9 | | | |
| 5 | Dec 81 | .9 | 2.5 | .02 | Not Signifi. | ---- | -1.9 | 2.1 | .35 | Significant | 5<6 |
| 6 | | .9 | 2.3 | | | | -1.6 | 2.2 | | | |
| 5 | Jan 82 | - .5 | 3.5 | .15 | Not Signifi. | ---- | -3.7 | 4.6 | .43 | Significant | 5<6 |
| 6 | | - .4 | 3.2 | | | | -3.3 | 4.8 | | | |
| 5 | Feb 82 | 2.0 | 2.2 | .55 | Significant | 5>6 | -1.6 | 2.5 | .18 | Not Signifi. | ---- |
| 6 | | 1.4 | 1.9 | | | | -1.5 | 2.7 | | | |
| 5 | Mar 82 | 6.1 | 2.1 | 1.14 | Significant | 5>6 | - .8 | 1.4 | .122 | Not Signifi. | ---- |
| 6 | | 5.0 | 1.6 | | | | - .9 | 1.3 | | | |
| 5 | Apr 82 | 8.2 | 4.0 | .98 | Significant | 5>6 | - .2 | 1.3 | .22 | Significant | 5>6 |
| 6 | | 7.2 | 3.9 | | | | - .4 | 1.4 | | | |

## SWAMP LAKE WEATHER STATIONS

(Elevation: Approximately 1,000')

Station #7 - Slash FC; Planted 1974
Station #8 - 2nd Growth HF; Established 1959, spaced 1974
Station #9 - Mature HC

| Station (#) | Month | MAXIMUM MONTHLY TEMPERATURE | | | | | MINIMUM MONTHLY TEMPERATURE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. Temp. ($\bar{x}$ S.D.) | | Max. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) | Min. Temp. ($\bar{x}$ S.D.) | | Min. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) |
| 7 | June 81 | 15.7 | 3.4 | 1.4 | Signifi. | 7>8 | 7.2 | 2.0 | .73 | Signifi. | 7<8 |
| 8 | | 16.2 | 3.6 | | | | 8.0 | 2.4 | | | |
| 7 | July 81 | 21.5 | 4.1 | .58 | Signifi. | 7<8 | 8.5 | 2.7 | .48 | Signifi. | 7<8 |
| 8 | | 22.1 | 3.9 | | | | 9.0 | 2.5 | | | |
| 7 | Aug 81 | 23.6 | 6.0 | .13 | Not Signifi. | ---- | 8.7 | 2.8 | .89 | Signifi. | 7<8 |
| 8 | | 23.7 | 5.7 | | | | 9.5 | 2.4 | | | |
| 7 | Sept 81 | 17.6 | 5.6 | .92 | Signifi. | 7>8 | 6.2 | 2.9 | .49 | Signifi. | 7<8 |
| 8 | | 16.7 | 4.9 | | | | 6.7 | 2.7 | | | |
| 7 | Oct. 81 | 12.5 | 3.2 | 1.6 | Signifi. | 7>8 | 2.3 | 3.5 | .49 | Signifi. | 7<8 |
| 8 | | 10.9 | 2.2 | | | | 2.8 | 3.3 | | | |
| 7 | Nov 81 | 7.1 | 3.0 | 1.5 | Signifi. | 7>8 | 1.8 | 3.7 | .24 | Not Signifi. | ---- |
| 8 | | 5.9 | 2.3 | | | | 1.5 | 3.8 | | | |
| 7 | Dec. 81 | 2.2 | 2.6 | .9 | Signifi. | 7>8 | -3.4 | 3.4 | .71 | Not Signifi. | ---- |
| 8 | | 1.3 | 2.4 | | | | -2.7 | 2.7 | | | |
| 7 | Jan 82 | -0.0 | 3.1 | .23 | Not Signifi. | ---- | -5.4 | 5.7 | .88 | Signifi. | 7<8 |
| 8 | | -0.5 | 3.4 | | | | -4.8 | 5.3 | | | |
| 7 | Feb 82 | 2.1 | 2.4 | .4 | Not Signifi. | ---- | -3.8 | 3.5 | 1.53 | Signifi. | 7<8 |
| 8 | | 2.5 | 2.0 | | | | -2.2 | 3.4 | | | |
| 7 | Mar 82 | 7.8 | 2.6 | 1.35 | Signifi. | 7>8 | -3.2 | 2.6 | .71 | Signifi. | 7<8 |
| 8 | | 6.4 | 2.1 | | | | -2.6 | 2.2 | | | |
| 7 | Apr 82 | 9.8 | 4.3 | .04 | Not Signifi. | ---- | -2.9 | 2.3 | 1.22 | Signifi. | 7<8 |
| 8 | | 9.9 | 4.5 | | | | -1.7 | 1.9 | | | |

SWAMP LAKE WEATHER STATIONS

(Elevation: Approximately 1,000')

| Station (#) | Month | MAXIMUM MONTHLY TEMPERATURE | | | | | MINIMUM MONTHLY TEMPERATURE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. Temp. ($\bar{x}$) | S.D.) | Max. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) | Min. Temp. ($\bar{x}$) | S.D.) | Min. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) |
| 7 | June 81 | 15.7 | 3.4 | 1.7 | Signifi. | 7>9 | 7.2 | 2.6 | .87 | Signifi. | 7>9 |
| 9 | | 14.0 | 3.0 | | | | 8.1 | 1.5 | | | |
| 7 | July 81 | 21.5 | 4.1 | 1.6 | Signifi. | 7>9 | 8.5 | 2.7 | 1.53 | Signifi. | 7<9 |
| 9 | | 19.9 | 3.8 | | | | 10.0 | 2.4 | | | |
| 7 | Aug 81 | 23.6 | 6.0 | 2.17 | Signifi. | 7>9 | 8.7 | 2.8 | 1.79 | Signifi. | 7<9 |
| 9 | | 21.4 | 5.3 | | | | 10.5 | 2.4 | | | |
| 7 | Sept 81 | 17.6 | 5.6 | 2.66 | Signifi. | 7>9 | 6.2 | 2.9 | 1.20 | Signifi. | 7<9 |
| 9 | | 14.9 | 4.1 | | | | 7.4 | 2.4 | | | |
| 7 | Oct. 81 | 12.5 | 3.2 | 2.28 | Signifi. | 7>9 | 2.3 | 3.5 | 1.21 | Signifi. | 7<9 |
| 9 | | 10.2 | 2.2 | | | | 3.6 | 2.9 | | | |
| 7 | Nov. 81 | 7.1 | 3.0 | 1.15 | Signifi. | 7>9 | 1.8 | 3.7 | .45 | Signifi. | 7<9 |
| 9 | | 5.9 | 2.3 | | | | 2.2 | 3.4 | | | |
| 7 | Dec. 81 | 2.2 | 2.6 | .84 | Signifi. | 7>9 | -3.4 | 3.4 | 1.45 | Signifi. | 7<9 |
| 9 | | 1.4 | 2.3 | | | | -1.9 | 2.5 | | | |
| 7 | Jan. 82 | -0.0 | 3.1 | .50 | Not Signifi. | ---- | -5.4 | 5.7 | 1.22 | Signifi. | 7<9 |
| 9 | | -0.7 | 3.3 | | | | -4.5 | 5.3 | | | |
| 7 | Feb 82 | 2.1 | 2.4 | .37 | Not Signifi. | ---- | -3.8 | 3.5 | .80 | Signifi. | 7<9 |
| 9 | | 1.8 | 2.1 | | | | -3.0 | 3.5 | | | |
| 7 | Mar 82 | 7.8 | 2.6 | 2.19 | Signifi. | 7>9 | -3.2 | 2.6 | 1.83 | Signifi. | 7<9 |
| 9 | | 5.6 | 2.0 | | | | -1.4 | 1.7 | | | |
| 7 | Apr 82 | Insufficient Data | | | | | | | | | |
| 9 | | | | | | | | | | | |

SWAMP LAKE WEATHER STATIONS

| Station (#) | Month | MAXIMUM MONTHLY TEMPERATURE Max. Temp. ($\bar{x}$ S.D.) | Max. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) | MINIMUM MONTHLY TEMPERATURE Min. Temp. ($\bar{x}$ S.D.) | Min. $\bar{x}$ Diff. | Paired T-Test ($\alpha$=0.05) | Significance ( > or < ) |
|---|---|---|---|---|---|---|---|---|---|
| 8 | June 81 | 16.2 3.6 | 2.2 | Signifi. | 8>9 | 8.0 2.4 | .13 | Not Signifi. | ---- |
| 9 | | 14.0 3.0 | | | | 8.1 1.5 | | | |
| 8 | July 81 | 22.1 3.9 | 2.2 | Signifi. | 8>9 | 9.0 2.5 | 1.04 | Signifi. | 8<9 |
| 9 | | 19.9 3.8 | | | | 10.0 2.4 | | | |
| 8 | Aug 81 | 23.7 5.7 | 2.3 | Signifi. | 8>9 | 9.5 2.4 | .91 | Signifi. | 8<9 |
| 9 | | 21.4 5.3 | | | | 10.5 2.4 | | | |
| 8 | Sept 81 | 16.7 4.9 | 1.74 | Signifi. | 8>9 | 6.7 2.7 | .71 | Signifi. | 8<9 |
| 9 | | 14.9 4.1 | | | | 7.4 2.4 | | | |
| 8 | Oct. 81 | 10.9 2.2 | .68 | Signifi. | 8<9 | 2.8 3.3 | .76 | Signifi. | 8<9 |
| 9 | | 10.2 2.2 | | | | 3.6 2.9 | | | |
| 8 | Nov 81 | 5.9 2.7 | .026 | Not Signifi. | ---- | 1.5 3.8 | .69 | Signifi. | 8<9 |
| 9 | | 5.9 2.3 | | | | 2.2 3.4 | | | |
| 8 | Dec 81 | 1.3 2.4 | .05 | Not Signifi. | ---- | -2.7 2.7 | .73 | Signifi. | 8<9 |
| 9 | | 1.4 2.3 | | | | -1.9 2.5 | | | |
| 8 | Jan 82 | -0.5 3.4 | .22 | Signifi. | 8>9 | -4.8 5.3 | .34 | Signifi. | 8<9 |
| 9 | | -0.7 3.3 | | | | -4.5 5.3 | | | |
| 8 | Feb. 82 | 2.5 2.0 | .77 | Signifi. | 8>9 | -2.2 3.4 | .73 | Signifi. | 8>9 |
| 9 | | 1.8 2.1 | | | | -3.0 3.3 | | | |
| 8 | Mar 82 | 6.4 2.1 | .84 | Signifi. | 8>9 | -2.6 2.2 | 1.26 | Signifi. | 8<9 |
| 9 | | 5.6 2.0 | | | | -1.4 1.7 | | | |
| 8 | Apr 82 | Insufficient Data | | | | | | | |
| 9 | | " " | | | | | | | |

PROGRESS REPORT

TITLE (E.P. #):

Landsat Classification System for Wildlife Habitat Management and Research Planning. (E.P. 913)

PROJECT SUPERVISOR:

Rick Ellis, Ministry of Forests, Victoria. 387-3144

PROJECT LEADER:

Karen Sadoway, Research Branch, Ministry of Forests, 1450 Government Street, Victoria, B.C. V8W 3E7. 387-3542

STAFF:

K. Sadoway

PERIOD COVERED:

April 1 - September 30, 1982

## 1 SUMMARY

A problem analysis revealed that Landsat imagery could provide a broad wildlife habitat classification system. A working plan was developed and was designed to compare three Landsat classification methodologies in terms of cost, accuracy, precision and utility of the resulting classification system. Each was individually contracted to an analyst and the final analyses were then comparatively evaluated under a separate contract. The three Landsat image classification analyses have been completed. The comparative evaluation is complete and the final report is being reviewed.

## 2 INTRODUCTION

As part of the Integrated Wildlife Intensive Forestry Research (IWIFR) program, a problem analysis was initiated to determine if Landsat image analysis could provide a wildlife habitat classification system suitable for wildlife-forestry research.

The analysis revealed that while Landsat imagery cannot provide a detailed wildlife habitat classification system, it can provide a broad classification system which is current, accessible and can be quickly and efficiently inventoried.

A working plan designed to evaluate 3 methods of Landsat classification analysis and the usefulness of the resulting classification systems was developed. The project is in its final stage. The three initial analyses have been completed and the final comparative evaluation is currently being reviewed.

## 3 OBJECTIVES

a) To evaluate three Landsat image classification methodologies: 1) paper print analysis; 2) positive transparency analysis; and 3) digital computer tape (DICS) analysis.
b) To evaluate the classification systems developed.

## 4 METHODS

Three Landsat image formats - paper print, positive transparency, digital computer tape - provided the data to develop three wildlife habitat classification maps for the study area defined by NTS quadrants 92L 4,5 and 92K 1,8.

Each analyst was provided with their particular Landsat image format, black and white aerial photographs, and NTS Topographic maps of the study area. They were requested to develop the best wildlife habitat classification map possible for their method of analysis without a habitat field survey.

Each analyst was required to produce a report describing the methodology of map production, cost, time, materials, predicted accuracy and precision. The wildlife habitat classification map was to accompany the report.

Upon completion of the three Landsat image analyses, a comparative evaluation was undertaken to determine which method was most suitable based on accuracy, utility and cost-effectiveness.

Accuracy was assessed through a field and office check. Utility was evaluated using a questionnaire survey. The cost comparison was based on figures provided by the analysts for professional and technical services, travel expenses (when vital to the analysis), mapping materials, and computer time (when applicable).

A report describing the methods used for the comparison evaulation and discussing the results was produced.

## 5 RESULTS

A draft of the final report has been completed.

## 6 REPORTS COMPLETED

| | STATUS |
|---|---|
| Landsat Classification for Wildlife Habitat Management and Research Planning: Problem Analysis | At Press |
| Landsat Classification: Evaluation of Image Analysis Methodologies for Wildlife Habitat Management and Research Planning: Working Plan | At Press |

| | |
|---|---|
| Landuse and Land Cover Classification and Mapping of the Sayward Forest Using Landsat Imagery and a Colour Additive Viewer | Final Draft |
| Landsat Paper Print Analysis for Wildlife Habitat Mapping | Final Draft |
| Evaluation of Landsat Digital Data for a Wildlife Habitat Classification on Vancouver Island | Final Draft |
| Evaluation of Three Methods of Wildlife Habitat Mapping Using Landsat Imagery | Draft |

7 PLAN FOR THE NEXT 6 MONTHS

Approval of comparative evaluation report and publication of reports.

PROGRESS REPORT

TITLE (E.P. #):

Developing a Wildlife-Habitat Management System (MANATAT). (E.P. 914).

PROJECT SUPERVISOR:

Rick Ellis, Ministry of Forests, Victoria. 387-3144

PROJECT LEADER:

Kim Scoullar, Life Science Programming Ltd. #906-5775 Toronto Road, Vancouver, B.C. V6T 1X4 224-1158

STAFF:

Kim Scoullar

PERIOD COVERED:

April 1 - September 30, 1982

## 1 SUMMARY

Alternative approaches for predicting the effects of forest management activities on habitat availability for a wildlife species have been identified, and the most practical approach has been selected and developed. Criteria for selecting the method included minimizing data requirements and cost of application while maximizing predictive accuracy and flexibility of application. Although the biological understanding, data requirements, computing techniques and analysis method have been described in detail, the computer programs needed to implement the approach have yet to be written, and test applications for deer and elk have yet to be initiated.

The approach developed involves understanding what the animal's needs are, establishing the extent to which these needs are satisfied within an area, and projecting changes in the area over time. This philosophy has been used by wildlife biologists in British Columbia from the outset, but the complexity of applying this approach has restricted its utility to qualitative judgements for small areas by experienced biologists working in the field. The method developed here would facilitate quantitative analysis for large areas by using computer programs (Manatat) to handle the complexity, and grid maps to represent field conditions. Future versions of the grid maps would be projected using a program which considers changes due to plant growth and forest management activities, so that changes in habitat availability may be predicted. Layout cards have been designed to assist in planning the best way to use available wildlife information with existing maps when applying the approach using the proposed Manatat computer programs.

## 2 INTRODUCTION

The population density of a wildlife species in an area fluctuates according to factors such as weather, predators, parasites, disease and hunting pressure. We are limited in our ability to predict trends in these factors, and thus we are unable to predict population fluctuations. However, population density fluctuates around the level fixed by the capacity of the area to support individuals of the species. This capacity may itself fluctuate with weather under the pressure of use by the species, but with the appropriate habitat and wildlife data, with maps of the area, and with an understanding of how to interpret this information, we can predict the carrying capacity under the conditions to which the data pertain.

An understanding of the habitat requirements of deer and elk, and of the many different ways in which intensive forest management affects the habitat available to these wildlife species, is being developed through field studies

supported by the IWIFR Program. However, the complex nature of these forestry-wildlife interactions prohibits direct application of this information to predict the carrying capacity during different seasons over large areas of forested land, or to project future changes in these carrying capacities as a result of plant growth and forest management activities (Manatat: Problem Analysis).

Most of the complexity of applying our understanding over vast areas of land results from the need to repeat the application for every small area of land which is mapped as a different type, to analyse the spatial mosaic distribution of different mapping types, and to duplicate these applications and spacial analysis for different seasons. Future conditions for each small area of land must then be projected, and the entire application process repeated for each future time. Fortunately, all of this tedious and repetitive work can be handled by computer programs using digitized land maps and wildlife information in data files. A set of programs suitable for a wide variety of wildlife species and land types has been designed (Manatat: Working Plan).

The remaining complexity results from the method for determining the carrying capacity of a small area of land during one season at one point in time. Regardless of whether this calculation is performed by hand or using a computer, decisions must be made regarding how to use what wildlife data with which maps. The Manatat computer programs will provide alternative procedures from which to choose, with the data and map requirements of each procedure clearly defined. These programs act as building blocks which combine to form a framework for the method of determining carrying capacity, as well as for the application of that method to large areas of land and the repeated application over seasons and future times.

## 3 OBJECTIVES

To produce a practical method for:

a) Predicting a number of indices of the habitat situation for a wildlife species over an area of forested land;

b) Repeating that prediction for different seasons to allow for comparisons between seasons;

c) Projecting changes in forest conditions with plant growth and forest management, and predicting the habitat situation over seasons for future times;

where the 'habitat situation' includes the quantity, quality and distribution of habitat for wildlife species.

## 4 METHODS

The task is to develop a system to be used as a tool for managing wildlife habitat. The method for developing this system initially included consulting with wildlife, forestry, mapping and computer experts, reading relevant information, compiling notes of forestry-habitat-wildlife interactions and of studying computing techniques which might prove useful for representing those interactions. Subsequently the method has included identifying alternatives for using this understanding and these techniques to accomplish the task, developing criteria for evaluating these alternatives, and using the criteria to select the most appropriate alternatives for a complete system.

Previous work as reported in the literature has contributed very little to this project other than to stimulate thought and to identify alternatives that were not appropriate to satisfying the objectives. Most of the results of this project are the product of original thinking from basic principles by the author and by participants in the many workshops, seminars and meetings promoted by the IWIFR program and attended by individuals from government, industry and educational institutions.

# 5 RESULTS AND DISCUSSION

The results to date concern the selection of an approach for predicting the habitat situation for any wildlife species in any area at any time, and the development of a practical method for implementing this approach over large areas of land at different times. The approach selected has been used by experienced wildlife biologists in British Columbia from the outset: understanding what the animals need, estimating the extent to which these needs are satisfied within an area, and projecting changes in the area over time. Unfortunately, this approach is too complicated to do by hand or in your head except for special cases. Before discussing these complications and the method developed for handling this complexity, consider the following alternative approaches and the reasons for their rejection.

It is not practical to produce maps of habitat distribution for a wildlife species from field reconnaissance, with mapping units formulated according to the habitat requirements of the species. The resulting maps would be useful only for that species in that area, and the map would be outdated with plant growth and forest management.

It is not sufficient to correlate intensity of use by individuals of a wildlife species with the mapping types of an existing land map to predict habitat availability (e.g. Thomas 1979; Scoullar 1980) as this approach ignores information on habitat requirements and may give misleading results. For example, deer winter habitat may correlate with the mature timber forest types of a forest cover map, but not all mature stands provide winter habitat. Land maps may be overlayed to improve the correlation. For example, overlaying a topography map with a forest cover map should increase the correlation of use with mature stands on low elevation south slopes, and decrease the correlation with mature stands on high elevation north slopes. This improvement may be satisfactory for a particular purpose such as predicting deer winter range, but for computing the habitat value of a large area the approach suffers from a massive increase in data requirements for each small increase in accuracy. For example, overlaying two maps with ten

mapping types on each produces one hundred possible combinations to be considered, while adding a third map with ten types increases this to one thousand possible combinations to be censused. The amount of data to be collected would be reduced by eliminating combinations which do not occur. However, measurements would be needed for each mapping type under each management scenario, and a separate set of data would be required for each season (Manatat: Problem Analysis).

Alternatively, predictions of the habitat situation for a wildlife species over an area of land can be obtained by using habitat requirement information with land maps and data on the mapping types to interpret the distribution of each habitat requirement of a wildlife species. For example, data defining the requirement of deer for thermal cover could be used with forest cover and topographic maps to predict the distribution of thermal cover by collecting data on each forest cover-topographic mapping type combination. The data collected could be direct measures of thermal cover, or thermal cover values could be interpreted from attributes of the mapping types such as canopy height, canopy closure, elevation and aspect. These measurements are not sensitive to population fluctuations. Both the direct measures and the attributes for interpretation are much easier to obtain than are the censuses of use by individuals of the species required by the methods mentioned above. However, the process must be repeated for each habitat requirement, and the resulting distributions of each requirement must be combined by considering the locomotive abilities of the species. For example, the distributions of food and of security cover may also be determined for deer, and the food available to support deer may be reduced when thermal or security cover are not available in the immediate vicinity. The extent of reduction depends on the distances involved and on the ease with which the species can cover these distances.

The approach selected consists of using habitat data to interpret the habitat situation from land maps, which amounts to a simulation of the biology of habitat selection by the wildlife species. It would be a formidable task

to represent all aspects of habitat selection, but enough details can be included to feel confident of the predictions made. It is not possible to consider unpredictable factors such as weather or predator and parasite population fluctuations, and it is not possible to predict actual population levels without considering these factors. Consequently, the understanding of the habitat situation would be constrained to predictions of the population size which the habitat has the potential to support. This constraint does not reduce the utility of the approach for understanding the effects of land management scenarios on the habitat situation for a wildlife species because the management activities can be recorded on the maps used in making the predictions. The potential carrying capacity could form the basis to which the effects of hunting and/or predation could be added at some future date.

Applying the approach for an area involves performing a number of tasks, namely: obtain and overlay land maps; interpret amount of food supplied, other requirements provided, or preclusion caused by different mapping types; apply the interpreted values to the appropriate map; analyse the spatial distribution of a requirement provided or of a factor causing preclusion by considering locomotive abilities; reduce values on the map of food supplied to allow for accessability of other requirements and for the proximity of factors causing preclusion; calculate carrying capacity by comparing food supplied with food requirements; compare carrying capacity between seasons or years; and project future versions of the maps to be used for predicting changes in the habitat situation over time. The same task may have to be performed repeatedly to complete a habitat situation prediction. For example, the tasks of obtaining, overlaying, interpreting, and analysing the spatial distribution of one habitat requirement such as thermal cover may have to be repeated for a second requirement such as security cover. Some tasks would be identical for both situations, such as getting the same forest cover map for use in each interpretation, while other tasks would differ between interpretations, such as spatial analysis of thermal cover distribution versus spatial analysis of security cover distribution.

All of the tasks necessary for a particular application together form a network of tasks, with branches of the network converging to avoid repeating identical tasks, and diverging when the tasks differ. The problem faced by someone preparing to predict the habitat situation for a wildlife species is to decide which tasks must be performed, in what order, requiring what information, and to identify identical tasks which do not need to be repeated. Identifying identical tasks is most important when repeating a prediction for future times, as only those tasks relating to maps which change over time need to be repeated.

To assist in identifying and organizing the desired network of tasks, each kind of task has been described with a flowchart, and each flowchart has been abbreviated in the form of a layout card. Each layout card records the name of the task, the input requirements, the output products, and the different tasks which might preceed or follow the task. All tasks are identified by a single letter of the alphabet so that linkages between tasks may be specified using these letters. The layout cards contain blank boxes into which a user may write the name of input used or output produced, a list of letters specifying alternative preceeding tasks, and a list of letters specifying alternative subsequent tasks. A user may then plan an application of the approach by linking the various layout cards to form a network of tasks to be performed, and by filling in the cards to determine the input data required and the output results expected. The user may refer to the flowchart for each task when more detail on the task is required.

The selected approach may be applied by hand, but many of the tasks which involve analysis of entire maps would be too tedious for inclusion in the application. For example, spatial analysis involves measuring the distance from everywhere to everywhere, with distances measured by travel time using the easiest path. It is not reasonable to expect people to perform spatial analysis on paper maps using a ruler to measure distances, determining the easiest path for each measurement by looking at a different map which shows ease of movement, and calculating the travel time for each measurement by

considering the distance through areas of different ease of movement and the locomotive abilities of the animals. This project has defined in detail a method for using computer programs to complete the tedious calculations. A separate program would be written for each type of task, so that the programs would serve as modules in a network of modules. The user would use the modules according to the procedure outlined by the layout cards. Together, the modules of a network could be considered as a "computer simulation model" of habitat selection, but the programs would be more accurately described as "map processing programs".

Implementing the approach with the aid of computer programs will require some additional tasks to be performed, namely: digitize maps and convert to grid form; prepare files containing attributes of mapping types, rules for interpretation, calibration data for rules and data on food requirements; and prepare a file containing a table for projecting future versions of a map. In addition to calculating the potential carrying capacity of an area, the programs could provide information such as: the distribution of resources satisfying a requirement or of factors causing preclusion; the distribution of carrying capacity; the distribution of areas that would be used except for the lack of one requirement or the presence of one factor causing preclusion; and the distribution of changes in carrying capacity between years or seasons.

The map processing programs needed to predict the habitat situation at one point in time, and to project future versions of the maps used therein, would be collectively known as Manatat. Prediction of specific habitat situations (e.g. deer winter range) would be possible using only a few of the program modules. The resulting predictions would differ from those presently produced as Manatat would calculate habitat values for all areas (e.g. winter range would be those areas rating the highest) and the values would be expressed in terms of potential carrying capacity (i.e. quantitative values rather than yes/no occurance). For research purposes, the full power of Manatat could be utilized and the results compared with field observations as a test of the

understanding expressed when preparing the network of layout cards (i.e. the understanding of habitat requirements, of resources satisfying those requirements, of factors causing preclusion, and of the interaction between different requirements and different preclusion factors).

For commercial purposes, such as developing multiple-use management plans for harvested forests, a compromise between predictive accuracy and cost of application might be necessary. Cost of application will increase when the application involves large areas of land, and when the complexity of the application requires much data to be collected and much computer time for the analysis. A typical compromise might constrain the application to include only: food (including covering by snow in winter) plus three other requirements (e.g. thermal cover, security cover, open water) and one factor causing preclusion (e.g. human disturbance), over three season (e.g. winter, spring and summer), for the present time and for two future times (e.g. short term [10 years] and long term [50 years]). Completing the analysis for the present time and for future times under different management scenarios will give resource managers quantitative predictions of the effects on wildlife habitat of different management alternatives.

| 6 REPORTS COMPLETED | STATUS |
|---|---|
| Problem Analysis: Developing a Wildlife-Habitat Management System | first draft |
| Working Plan: Part One: Overview | first draft |
| Working Plan: Part Two: Interpretive Maps | first draft |
| Working Plan: Part Three: Spatial Analysis | first draft |

| | |
|---|---|
| Working Plan: Part Four: Future Projection | first draft |
| Users Manual: Procedure Flowcharts | first draft |
| Users Manual: Application Layout Cards | first draft |

## 7 PLAN FOR NEXT WORK PERIOD

The method for Manatat has been defined in the Working Plan in sufficient detail to allow an analysis to be completed by hand, but it is unlikely that anyone would want to undertake such a task. The method was designed with the intention of having a computer perform the analysis, and without the step of implementing the system on a computer by writing the necessary series of computer programs, the potential of the method will never be realized. Therefore, writing these programs should receive top priority once the problem analysis and working plan have been circulated in second draft form. Writing the programs would involve much labour and some computing costs.

A person wishing to apply the Manatat computer programs as a research or management tool would need specific instruction on organizing the application, preparing input grids and data files, running the programs, and interpreting the output. This information should be contained in a Users Manual which would be written to accompany the programs. The flowcharts for each procedure and the layout cards for organizing procedures have already been prepared for inclusion in the Users Manual.

The completed system will need to be tested in a research situation before being applied as a management tool. The deer and elk studies presently funded under the IWIFR Program are the logical choices for two independent test applications. Workshops would be needed to plan the application for each species using the layout cards. These workshops would identify the maps to be used and the wildlife and mapping data needed. The maps would need to be digitized, and the data entered into data files. Algorithms for interpreting maps would need to be formulated and inserted into the interpretation program and the programs run to produce the test results.

# 8 LITERATURE CITED

Scoullar, K.A. 1980. Using land resource maps to define habitat for forest birds. M.Sc. Thesis. Faculty of Forestry, University of B.C. Vancouver, B.C. 295 p.

Thomas, J.W. (ed.) 1979. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. US Department of Agriculture, Forest Service. Agriculture Handbook No. 553. 512 p.

PROGRESS REPORT

TITLE (E.P. #):

Effects of Intensive Forest Management on Non-Ungulate Wildlife. E.P. 916

PROJECT SUPERVISOR:

Rick Ellis, Ministry of Forests, Research Branch, Victoria. 387-3144

PROJECT LEADER:

Karen Sadoway, Research Branch, Ministry of Forests, 1450 Government Street, Victoria, B.C. V8W 3E7. 387-3542

STAFF:

K. Sadoway

PERIOD COVERED:

April 1 - September 30, 1982

1 SUMMARY

In response to a growing concern for the management of all species and an increase in intensive forest practices, a problem analysis on the effects of intensive forest management on non-ungulate wildlife was initiated. Due to the number of species which occur on Vancouver Island, the analysis was divided into three sections: 1) amphibians and reptiles 2) mammals (excluding deer and elk) and 3) birds (breeding species only). The major topics discussed are species habitat requirements and the effects of intensive forest practices on these species. The analysis is in progress.

## 2 INTRODUCTION

In response to demand for management of all wildlife species and an increase in intensive forest practices, a problem analysis for 'non-ungulate' species on Vacouver Island was initiated. This analysis is designed to reveal the status of information on species habitat requirements and the effects of intensive forest practices on these species.

## 3 OBJECTIVES

To define research questions and priorities regarding habitat needs of non-ungulate wildlife on Vancouver Island (including other mammals, birds, reptiles and amphibians) and the effects of intensive forest management on these animals.

## 4 METHODS

From a review of the literature, information is being compiled on the habitat requirements and the effects of forest management on 'non-ungulate' species of Vancouver Island.

Species management objectives, established and projected management programs and public demands are also discussed. Consultation with key personnel has provided an additional source of information.

The problem analysis is divided into three sections: 1) amphibians and reptiles; 2) mammals; and 3) birds. The analysis includes 193 species: 12 amphibians, 7 reptiles, 35 mammals, and 139 birds. Each section will include a problem reference, species life history/ habitat requirement information, and recommended research topics designed to address known information gaps. Species and study topic priorities will be listed.

| 5 REPORTS COMPLETED | STATUS |
| --- | --- |
| Effects of Intensive Forestry Management on Non-Ungulate Wildlife | Two of three chapters drafted and reviewed. |

6 PLAN FOR THE NEXT 6 MONTHS

Complete report.

PROGRESS REPORT

TITLE (E.P. #):

Black-tailed Deer in Second Growth Forests on Vancouver Island.

PROJECT SUPERVISOR:

D.C. Morrison, Ministry of Environment, Nanaimo 758-3951

PROJECT LEADER:

R. Davies, Ministry of Environment, Nanaimo 758-3951

STAFF:

D. Doyle, B. Mason, P. Havard

PERIOD COVERED:

April 1 - September 30, 1982

## 1 SUMMARY

Information on habitat utilization and seasonal movements was collected on the 12 remaining radio collared deer as well as an additional 14 animals collared April - August 1982 (two subsequent losses to predation). Population counts, pellet group transects and wolf scat collections were completed for the summer period.

## 2 INTRODUCTION

With the rapid decline in mature timbered habitats on Vancouver Island, the future of the black-tailed deer (Odocoileus hemionus columbianus) management depends on integration of deer habitat requirements with intensive forest management policies. Research into the interaction of silvicultural treatments of second growth stands and deer habitat selection is necessary for an effective integrated resource management strategy.

This report outlines the progress made during the period of April 1, 1982 to September 31, 1982.

## 3 OBJECTIVES

The general objective of the deer project is to assess winter habitat selection in both mature and second growth habitats.

Specific objectives addressed by first year activities concern the establishment of baseline information on the various study sites.

The specific objectives include:

a) refining live capture techniques (live traps and chemical immobilization) of free ranging deer for the purpose of radio collaring.
b) documenting present habitat utilization and seasonal movements of radio collared deer.
c) establishing permanent pellet group transects through selected habitat types.
d) collecting data on predator food habits and distribution.

## 4 METHODS

Methodologies associated with monitoring deer habitat use and movements, population status and predator distribution were presented in the interim working plan.

## 5 RESULTS AND DISCUSSION

### 5.1 Habitat Utilization

#### 5.1.1 Radio telemetry

Fourteen additional collars were placed on deer in April through August (two were replacements for animals lost to predation by wolves). This brings the total of collared deer to 24 (20 in the south Nanaimo River study area, 3 in the Sayward study area and 1 in the Shawnigan site).

A comparison of immobilization techniques (daylight on foot vs night using lights and vehicles) is presented in Table 1. The greater efficiency of night time immobilization appears to be related to the fact that deer appear to retreat farther to cover during daylight hours thereby reducing the chance of finding the immobilized animal.

A summary of seasonal habitat use to date from radio location data is presented in Table 2 and 3. It is separated by study area, watershed, season and day and night intervals. All radio location information to date has been fortran coded for future analyses.

Table 1. Efficiency of immobilization techniques

| | a) Daylight hunting (Female Deer) | b) Night hunting (Female Deer) |
|---|---|---|
| Total man hours | 218 | 328 |
| No. of deer hit with dart | 31 | 29 |
| No. of deer successfully immobilizedq | 8 | 15 |
| Known no. of deer killed | 2 | 1 |
| Man hours per deer hit with dart | 7 | 11.3 |
| Man hours per deer successfully immobilized | 27.3 | 21.9 |
| % killed of deer hit | 6.4% | 3.4% |
| % deer immobilized of deer hit | 25.8% | 5.17% |

c) Clover trapping
66 trap days - 5 deer captured plus (2 broke out)

5.2 Population

5.2.1 Classified Counts

Spring classified counts are summarized in Table 4. The statistic to note is juvenile recruitment which dropped from a 4 year average (1978-1981) of 32.2 % to 9.9% in 1982. This is attributed to winter severity and predation.

August counts expresses as fawns/doe are summarized in Figure 1. The Nanaimo River data is included in the south island graph. The fawn/doe ratio is harder to interpret than juvenile spring ratios as changes in behavior due to increasing predation may affect our ability to observe fawns.

Table 2. Summary of habitat use from radio locations and sightings in south Nanaimo River

| SEASON | DAY OR NIGHT | NO. OF COLLARED DEER | TOTAL LOCATION | ACCURATE LOCATIONS | % ACCURACY | ROAD % | % 0-10 YEARS | % 11-20 YEARS | % 11-20 SPACED | % 21-30 YEARS | % 21-30 SPACED | % 31-50 YEARS | MATURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA - Nanamio River; Jump Creek | | | | | | | | | | | | | |
| Winter | Day | 7 | 29 | 16 | 55 | 0 | 25 | 12.5 | 0 | 0 | 31 | 0 | 31 |
| | Night | 0 | | | | | | | | | | | |
| Spring | Day | 9 | 69 | 64 | 93 | 1.5 | 30 | 23 | 0 | 19 | 14 | 0 | 12.5 |
| | Night | 2 | 3 | 3 | 100 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| Summer | Day | 12 | 163 | 58 | 97 | 2.5 | 13 | 33.5 | 2.5 | 21 | 9 | .5 | 18 |
| | Night | 11 | 32 | 31 | 97 | 0 | 45 | 33 | 0 | 10 | 3 | 3 | 6 |
| Total | | | 296 | 272 | 92 | 2 | 22 | 29 | 2 | 18 | 10 | 1 | 16 |
| AREA - Nanaimo River; Dunsmuir Creek | | | | | | | | | | | | | |
| Winter | Day | 2 | 6 | 5 | 83 | 0 | 0 | 60 | 0 | 0 | 40 | 0 | 0 |
| | Night | 0 | | | | | | | | | | | |
| Spring | Day | 6 | 44 | 33 | 75 | 0 | 34 | 18 | 0 | 24 | 18 | 0 | 6 |
| | Night | 0 | | | | | | | | | | | |
| Summer | Day | 10 | 109 | 97 | 89 | 0 | 19 | 23 | 0 | 36 | 14 | 2 | 6 |
| | Night | 8 | 29 | 27 | 93 | 0 | 67 | 22 | 0 | 11 | 0 | 0 | 0 |
| Total | | | 188 | 162 | 86 | 0 | 29 | 23 | 0 | 28 | 14 | 1 | 5 |

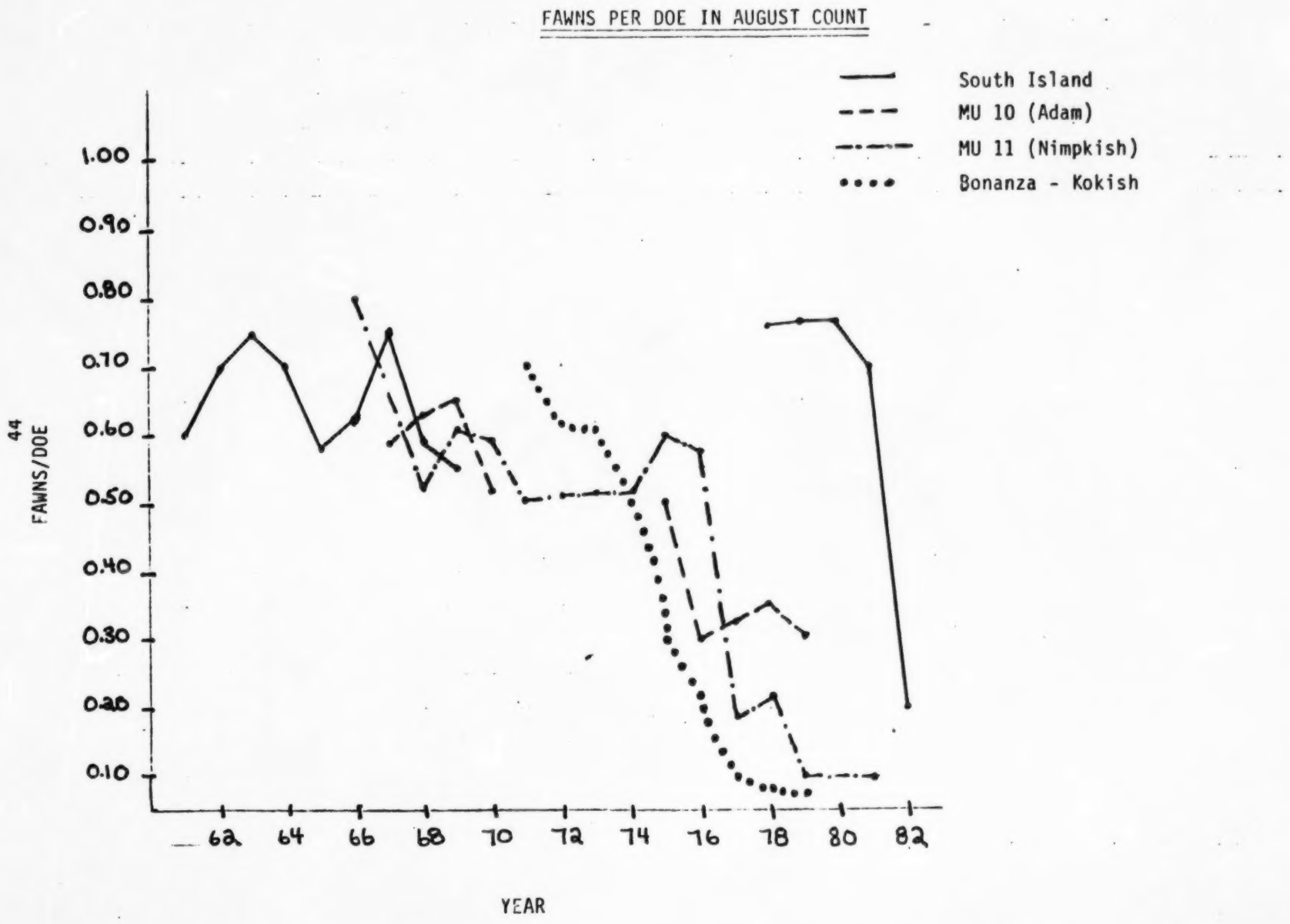
Table 3. Summary of habitat use from radio locations and sightings in Saywards and Shawnigan

| SEASON | DAY OR NIGHT | NO. OF COLLARED DEER | TOTAL LOCATION | ACCURATE LOCATIONS | % ACCURACY | % ROAD % | % 0-10 YEARS | % 11-20 YEARS | % 11-20 SPACED | % 21-30 YEARS | % 21-30 SPACED | % 31-50 YEARS | MATURE | SWAMP OR BOG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AREA - Sayward | | | | | | | | | | | | | | |
| Winter | Day | 1 | 1 | 1 | 100 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Night | | 0 | | | | | | | | | | | |
| Spring | Day | 2 | 2 | 1 | 50 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 |
| | Night | 1 | 1 | 1 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| Summer | Day | 3 | 14 | 14 | 100 | 0 | 14.5 | 28.5 | 0 | 0 | 7 | 28.5 | 14.5 | 7 |
| | Night | 3 | 5 | 5 | 100 | 0 | 80 | 0 | 0 | 0 | 0 | 20 | 0 | 0 |
| Total | | | 23 | 22 | 96 | 4.5 | 27.5 | 18 | 0 | 4.5 | 4.5 | 23 | 9 | 9 |
| AREA - Shawnigan | | | | | | | | | | | | | | |
| Spring | Day | 1 | 2 | 1 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 |
| Summer | Day | 1 | 4 | 4 | 100 | 0 | 0 | 75 | 0 | 0 | 0 | 0 | 25 | 0 |
| Total | | | 6 | 5 | 83 | 0 | 0 | 60 | 0 | 0 | 0 | 0 | 40 | 0 |

Table 4. Nanaimo River spring deer counts

| Classified Deer | | | | | Spotlight Counts | |
|---|---|---|---|---|---|---|
| YEAR | ADULT | YEARLING | TOTAL | % JUVENILE | NO. OF KM | DEER/KM |
| 1982 | 433 | 49 | 492 | 9.96 | 25.4 | 15.197 |
| 1981 | 170 | 65 | 235 | 27.60 | 19.2 | 18.600 |
| 1980 | 179 | 82 | 261 | 31.30 | 15.2 | 17.900 |
| 1979 | 132 | 71 | 203 | 24.90 | 15.2 | 18.900 |
| 1978 | 139 | 75 | 214 | 35.00 | 15.2 | 13.600 |

FIGURE 1


FAWNS PER DOE IN AUGUST COUNT
South Island
MU 10 (Adam)
MU 11 (Nimpkish)
Bonanza - Kokish
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
FAWNS/DOE
62
64
66
68
70
72
74
76
78
80
82
YEAR

## 5.3 Pellet Group Data

Permanent pellet group plots were established through various habitat types (mature and older second growth) using four 100 sq ft circular plots every 200 ft. Pellet groups will be counted and cleared spring and fall to separate summer and winter use. Initial results and transect locations were summarized in the interim working plan. Both t-tests (parametric) and Mann-Whitney (non-parametric - no assumption of normality) were run on the means of the habitat types. Both tests gave similar results, suggesting the data are normally distributed. When grouped according to mature vs. second growth, the mature is significantly greater at the .0001% level. Also individual mature blocks were significantly greater at the .0001 - .03% level than the closest adjacent second growth sites. As this was the first run of the transects, summer and winter use on the accumulation of pellet groups year to year cannot be separated out. Habitat use patterns in winter show up much better in cleared plots (Marika Townshend, unpublished data, Fish & Wildlife, Region 1). This will be the case in subsequent runs of the transects.

A small project involving testing pellet group data versus a known number of deer at the Morrel Wildlife Sanctuary in Nanaimo is continuing. Deer drives and sightings have indicated that there are only two mature deer (bucks) alive in the 22 acre deer enclosure. Two fawns (female?) have been released inside the enclosure and we hope to add two adult does before the end of October. This would bring the density to an equivalent of 175 deer per square mile. Forty-four pernament pellet group plots in the 22 acre site have been cleared for the winter period.

## 5.4 Predation

Selected roads were cleared of wolf scats in the Dunsmuir drainage of the Nanaimo River study area in late June and early July. Ninety-eight scats were removed from 15.6 km of roads. Fresh scats are continually being collected for future prey analyses.

The wolf removal plan is being implemented by Animal Control Officers Dan Lay and Don Hamilton in the Nanaimo River study area. No wolves have been removed as yet.

PROGRESS REPORT

TITLE (E.P. #):

Intensive Forestry Effects on Vancouver Island Deer and Elk Habitats. (E.P. 934)

PROJECT SUPERVISOR:

J.B. Nyberg, Ministry of Forests, Vancouver. 299-9151

PROJECT LEADER:

J.B. Nyberg, Ministry of Forests, Vancouver. 299-9151

STAFF:

L. Peterson, K. Spagnut

PERIOD COVERED:

April 1 - September 30, 1982

## 1 SUMMARY

During April through September 1982, the IWIFR 'habitat' research crew investigated understory (forage) responses to thinning and fertilization on 82 plots, completed wide-angle photography for canopy sampling on 16 plots, mapped 20 habitat types for elk in Grilse Creek, and established 7 new weather stations.

## 2 INTRODUCTION

Intensive forestry practices affect many of the habitat features that make good deer and elk range, including food supplies; cover from hunters and other predators; and shelter from snow, wind and cold. Properly applied, forestry may allow enhancement of deer and

elk habitats that have deteriorated through inappropriate management or forest succession. This research project is designed to investigate intensive silviculture treatments and their effects on forest ecosystems to determine where important beneficial and detrimental effects on deer and elk habitats will occur.

During February 1982, a problem analysis was completed which identified summer forage supplies and "winter range" as two important topics for research. Subsequently a working plan was prepared ("Intensive forestry effects on deer and elk forage") which described the research plan for the portion of the study conducted during the period covered by this progress report.

## 3 VEGETATION SAMPLING

During the summer, 82 plots were sampled to investigate understory plant responses to thinning and fertilization in stands older than 20 years. These plots had been previously established by the B.C. Forest Service and the Canadian Forestry Service in conducting research on stand responses to various thinning and fertilization intensities. Table 1 lists the characteristics of plots completed during the last six months. The long-term objective is to sample at least 2 replicates for each of the following treatment combinations: 4 levels of thinning (control [none], light, moderate and heavy) and two levels of fertilization (control and 225 kg N/ha) on 3 site types or hygrotopes (xeric, mesic and hygric) in 3 biogeoclimatic subzones (Wetter Coastal Douglas fir, Drier Coastal Western Hemlock, Wetter Coastal Western Hemlock).

In each plot, per cent cover of understory species was recorded on 30 quadrats. Details of plot selection and sampling methods can be found in the working plan. Data analysis will begin shortly.

4 LIGHT/OVERSTORY DENSITY

Wide-angle photography is being used to quantify light availability at 10 points on each plot. To date only 16 of the plots have been completed. The remainder will be photographed as time and weather conditions permit. Analysis of light availability (overstory canopy closure) will be conducted through the winter.

5 HABITAT MAPPING IN ELK HOME RANGES

Classification and mapping of elk habitats was completed for an area at Grilse Creek (Salmon River drainage) where elk movements had been intensively monitored for a week. Ecosystem associations and timber stands were used to distinguish 20 habitat types. Results of the habitat use analysis are described in the progress report for the IWIFR elk project.

6 WEATHER CONDITIONS

Two CR-21 electronic weather stations (Campbell Scientific, Inc.) were located during June in a natural opening and a nearby, closed-canopy immature stand in the lower Salmon River drainage. Weather data for the two stations have been collected continuously since then, but delays in decoding the information, which is recorded on cassette tapes, have prevented analysis so far.

In July, six of the nine other IWIFR weather stations were discontinued, although five of these were re-established in the lower Salmon River area to compare weather conditions in a variety of young growth habitats. Table 2 lists the attributes of the 5 new weather station locations. The other 3 weather stations were retained in their original locations to maintain continuity, should it be desirable to compare data from different areas and years.

Table 1. Number of plots sampled in each stratum during 1982[a]

| Biogeoclimatic subzone | Location | Treatment Levels: No thinning Unfert. | No thinning Fert. | Light Thinning Unfert. | Light Thinning Fert. | Moderate Thinning Unfert. | Moderate Thinning Fert. | Heavy Thinning Unfert. | Heavy Thinning Fert. |
|---|---|---|---|---|---|---|---|---|---|
| Wetter CDF | Menzies Creek | 2 | | 2 | | 2 | | | |
| | Cassidy | 2 | | | 2 | | 2 | | |
| | Mt. Brenton | 2 | | | 2 | | 2 | | |
| | Shawnigan L. | 4 | 6 | | | 4 | 4 | 4 | 4 |
| Drier CWH | Elk Bay | 2 | | | 2 | | 2 | | |
| | L. Cowichan | 2 | | | 2 | | 2 | | |
| | Merrill L. | 3 | | 3 | | 3 | | 3 | |
| Wetter CWH | Rupert Main | 2 | | | 2 | | 2 | | 2 |
| | Nimpkish | 2 | | 2 | | 2 | | | |

[a] Site type (hygrotope) descriptions are at present incomplete and are therefore not included.

Table 2. Attributes of the new weather station sites

| Weather Station | Surrounding Vegetation |
|---|---|
| Cr-21 #2257 | Boggy, open, with a few small trees |
| CR-21 #2258 | Densely stocked, immature western hemlock and Douglas fir |
| Standard station 1 | Not sufficiently restocked: essentially open |
| Standard station 2 | Douglas fir, 33 years old |
| Standard station 3 | Douglas fir, 31 years, spaced 1976 |
| Standard station 4 | Alder, 39 years |
| Standard station 5 | Douglas fir and alder, 30 years |

## 7 UPCOMING WORK

During the next six months, efforts will be concentrated on completing the photo sampling and conducting analysis of data collected during the summer. Habitat types will be mapped in deer winter ranges in the Nanaimo River study area. Also, extensive field work will be conducted, as weather conditions require, to describe snow, forage and stand characteristics in areas used by deer and elk during periods of deep snow. The working plan for this aspect of the study is in preparation and will be available shortly.

PROGRESS REPORT

TITLE (E.P. #):

Effects of Wolf Predation on Ungulates in Second Growth Forests (E.P. 937)

PROJECT SUPERVISOR:

Doug Janz, Ministry of Environment, Nanaimo. 758-3951

PROJECT LEADER:

Ian Hatter, Ministry of Environment, Victoria. 387-5921.

STAFF:

I. Hatter

PERIOD COVERED:

April 1 - October 30, 1982

## 1 SUMMARY

This project is a problem analysis designed to evaluate the potential effects and influences of predation, particularly by wolves, on ungulate populations in second growth forests. Predation on deer is particularly severe due to high wolf population densities on the Island and the probable additive effects of cougar and bear predation and human deer harvests. The potential influence of predation in affecting habitat selection by deer and elk is discussed. The present unknowns and potential problems of wolf predation in second growth forest management and research are listed and recommendations for future research are made.

## 2 INTRODUCTION

The IWIFR program has initiated a five year field research project to investigate how silvicultural practices in second-growth forests can be modified to enhance deer and elk populations. Preliminary predation studies in mature timber/early regenerating forests have shown that wolf predation has severely reduced deer populations, and indicate that ungulate responses to second growth forest treatments could be masked by predation. This has raised a major concern with IWIFR deer and elk researchers who feel that many of the conclusions derived from their research programs could be invalidated by the confounding effect of wolf predation.

## 3 OBJECTIVES

a) To review the effects and influences of wolf, bear and cougar predation on ungulate populations in North America and compare these to the predation effects documented for Vancouver Island.

b) To outline the potential effects and influences of wolf predation on ungulate populations in second growth forests.

c) To recommend studies for future research of predators and predator-prey relationships in second growth forests.

## 4 METHODS

A literature review of wolf, cougar, and bear predation was used to place predation findings on the Island in perspective with other regions in North America. Discussions with Fish and Wildlife Branch and Forest Service personnel and researchers served to identify the potential problems and unknowns of wolf predation on the IWIFR deer and elk research projects. A computer simulation model was used to help clarify the role of wolf predation in deer declines on northern Vancouver Island.

# 5 RESULTS AND DISCUSSION

The predation effects on black-tailed deer are particularly severe due to high wolf population densities and the probable additive effects of cougar and bear predation and human deer harvests. A computer simulation model supports the predator control hypothesis i.e. wolf predation acts as a limiting factor on deer at a level much lower than dictated by habitat carrying capacity. Predation effects on elk are poorly documented but appear less severe.

The confounding potential of wolf predation on the IWIFR programs are alluded to through hypothetical relationships between wolves, deer and elk in second growth forests. It is suggested that wolf densities will change rapidly in time and space with changes in deer density, thereby masking population responses to habitat manipulations. It is also suggested that wolves will increase summer movements and therefore home range sizes of elk cow:calf groups, as well as increase elk use of closed habitats. Deer may respond to wolf activity by migrating directly from winter onto summer home ranges, bypassing spring ranges where the concentration effect increases predation risk. Wolf hunting success rates are hypothesized to be highest in flat, open habitats. It is also suggested that as the elk:deer ratio increases in a watershed, utilization of elk by wolves will increase disproportionately.

It is recommended that research emphasis be directed towards the potential influence of predation on deer and elk habitat selection and to the capability of habitat manipulations to alter wolf-ungulate interactions. Logistical and financial constraints dictate that it will probably be necessary to select one IWIFR study area to measure predation influences on deer and elk, while reducing wolf numbers on other IWIFR study sites.

6 REPORTS COMPLETED

| | STATUS |
|---|---|
| Problem Analysis: Wolf Ecology and Predator-Prey Relationships on Vancouver Island | Final Draft |

7 PLAN FOR NEXT 6 MONTHS

Publication of report.